Spring 2021

INSPIRE Newsletter Spring 2021

Missouri University of Science and Technology. INSPIRE - University Transportation Center

TIER 1 UNIVERSITY
TRANSPORTATION CENTER (UTC)

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INSPIRE

INSPECTING AND PRESERVING INFRASTRUCTURE THROUGH ROBOTIC EXPLORATION

VOL. 5 | ISSUE 1 | SPRING
INSPIRE-UTC Biannual Publication

In this issue:

Awarded in December of 2016 by the U.S. Department of Transportation, the five-year **INSPIRE UTC** is a Tier 1 University Transportation Center with a research priority of preserving the existing transportation system as part of the UTC Program (https://www.transportation.gov/utc/2016-utc-grantees) that was authorized under the Fixing America's Surface Transportation Act.

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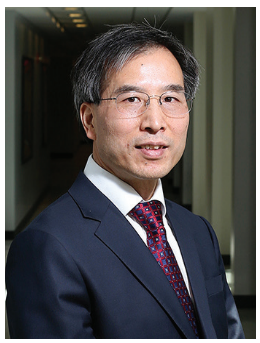
Director's Message

Greetings colleagues and friends! Since our last newsletter, the INSPIRE University Transportation Center (UTC) has achieved over 10,000 members on our email listserv and hosted various virtual events for additional interest and outreach.

The center continues to host webinars on a quarterly basis, engaging attendees worldwide on infrastructure and transportation related topics. The number of registrations for each recent webinar exceeded 200, an indication of increasing interest of the general audiences on the INSPIRE webinars over time.



The INSPIRE UTC team continues research and operation modifications due to the coronavirus and tries their best to minimize the impact of COVID-19 on various INSPIRE UTC research activities. Looking ahead, the INSPIRE UTC anticipates to host on-campus visitors in summer 2021 as Missouri S&T's students, faculty, and staff are getting ready to return to campus for in-person education experience.

The INSPIRE UTC continues to focus on ways to engage new and existing members of interest in transportation and infrastructure research. In this edition, we will highlight a continued feature of the Educational Module Series that serves as a lecture of completed research topics for undergraduate students from our community college minor partners.

This edition of newsletter will feature three articles focusing on data analytics and processing by INSPIRE UTC researchers. These studies include (1) The importance of accounting for soil effects in risk assessments of bridges subject to scour by Dr. Iris Tien from Georgia Institute of Technology, (2) Assistive intelligence: a collaboration between human and artificial intelligence for segmenting bridge elements from inspection video data by Dr. Ruwen Qin from Stony Brook University, and (3) Synchro-squeezed adaptive wavelet analysis for effective extraction of features from nonstationary data series by Dr. Genda Chen from Missouri University of Science and Technology.

Other highlights will include a successful workforce development initiative for academia, an introduction to Visual Inspection Research & Training Using Augmented Learning (VIRTUAL) laboratory, and a large-scale drone cage established for unmanned aerial vehicle research. This edition will also highlight the UTC Outstanding Student of the Year which is nominated by the INSPIRE UTC and selected by members at USDOT as well as community outreach with the National Society of Black Engineers on Traffic Jam! and the Kaleidoscope Discovery Center's Future City Competition.

We hope you enjoy the featured articles and exciting news of INSPIRE UTC, and invite you to visit our website at https://inspire-utc.mst.edu for additional information about upcoming events and webinars.

Genda Chen, Ph.D., P.E., F. ASCE, F. SEI, F. ISHMII
Director, INSPIRE University Transportation Center
Director, Center for Intelligent Infrastructure

NEWS

CII Establishes VIRTUAL Training Center

Fig. 1 Operation of a multicopter near a bridge

A new lab called VIRTUAL is under development at the Center for Intelligent Infrastructure (CII) which provides administrative support to the INSPIRE University Transportation Center (UTC). VIRTUAL stands for Visual Inspection Research & Training Using Augmented Learning. The lab will be equipped with cutting-edge technologies to allow students and researchers to explore mixed reality applications for infrastructure maintenance and bridge inspection. The objective of the lab is to boost the development of tools that enable both academia and industry to explore the research and application potential of physical-digital interaction environment offered by mixed reality techniques.

The VIRTUAL Lab will offer three-level robotic training programs that take advantage of many educational features offered by augmented reality. The training programs will implement the robots developed at the INSPIRE UTC to give users, inspectors in this case, a smooth transition and comprehensive training. At the first level, both a robot and a bridge will be simulated using a computational tool in a controllable background (virtual) environment. At the second level, a real robot and a virtual bridge will be simulated in a hybrid experimental/computational tool. At the third level, both a robot and a bridge will be prototyped for the ultimate training of inspectors in various real-world scenarios. At the end of laboratory training, inspectors will practice their skills at bridge sites (see Fig. 1).

Augmented reality turns, in real time, a real world into a digital interface by placing virtual objects in the real world. It will allow the center to take advantage of smart devices for interactive activities and communication, make actual measurements without contact, combine data sources for effective infrastructure management, and implement computer vision to help locate and assess defects and more. These capabilities are realized by using visualization tools, multilayer architecture of messages, imagery and background sounds, distance and area measurements (see Fig. 2), and classification of interested structural elements and damage types from artificial intelligence.

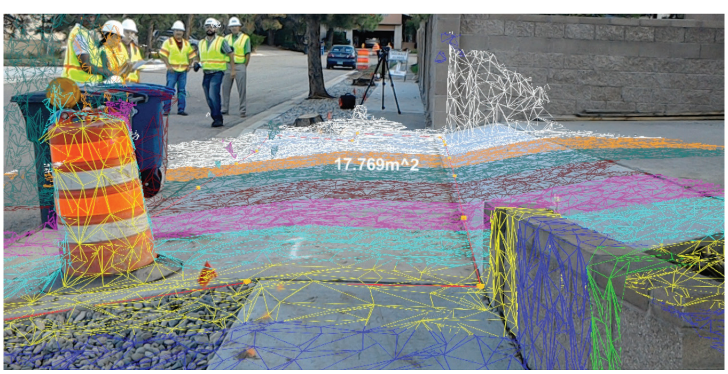


Fig. 2 Augmented reality for distance measurement

(Image courtesy of Los Alamos National Laboratory)

CHANCELLOR'S MESSAGE

What an exciting time to be at S&T! In October, we announced a $300 million gift from June and Fred Kummer to Missouri S&T to establish the Kummer Institute for Student Success, Research and Economic Development. Similar to the mission of INSPIRE, the aim of the Kummer Institute is to enhance research, education, workforce development and technology transfer.

The institute will feature four centers of excellence, including the Center for Advanced and Resilient Infrastructure to develop new approaches to rehabilitate and sustain the infrastructure that connects the businesses and communities that drive our state's economy. Also powered by the Kummer gift is a new Ph.D. fellowship program for innovation-minded students interested in pursuing a doctoral degree in a field of science, technology, engineering or mathematics. We anticipate great things and look forward to continued collaboration with INSPIRE.

I invite you to learn more at kummerinstitute.mst.edu.

Mo Dehghani, Ph.D.
Chancellor, Missouri S&T

Vice Chancellor of Research Visits Large Drone Test Lab

At noon time of March 16, 2021, Dr. Constantinos Tsatsoulis, Vice Chancellor of Research (VCR) at Missouri University of Science and Technology visited the HyPoint large drone facility for intelligent infrastructural remote and proximity sensing applications hosted by Dr. Genda Chen, Professor and Robert W. Abbett Distinguished Chair in Civil Engineering and Director of Center for Intelligent Infrastructure and INSPIRE University Transportation Center (UTC).

Dr. Chen introduced to VCR the long-term mission of INSPIRE University Transportation Center and the ongoing innovative research and development activities for smart infrastructure and transportation. The team led by Dr. Genda Chen and Dr. Liujun Li demonstrated both commercial and custom-made drone and robotics platforms and revolutionary multimodal sensing capabilities followed by table-top show, ground demonstration and live flight demos (see Fig.1). A number of graduate students worked hard to make this visit a success (see Fig. 2).

Fig. 1 VCR discussion with Dr. Liujun Li

The demonstrated robotics platform ranged from the "treefrog" climbing robot mechanism (with animation) for bridge scouring monitoring, palm-size DJI Tello drone by leverage of ceiling effect for substructure closeup inspection, commercial heavy-duty drone platform with ~15 lbs. payload and 16 min for hyperspectral/LiDAR/thermal/visible imaging with live-view for bridge deterioration conditions inspection and its high resolution spectral data and 3D point cloud registration, to Missouri S&T invention on Bridge Inspection Robot Deployment Systems (BIRDS). The drone ceiling attaching mechanism and the vision-based navigation and girder detection were demonstrated with the physical downscaled bridge girder for higher quality data collection (see Fig 3). Specialty military grade Anafi thermal drone and Elios2 carbon-fiber caged drone with multiple depth cameras and obstacle avoidance capability were also demonstrated for the complex bridge girder detailed inspection.

The hyperspectral and thermal imaging capabilities were also demonstrated to inspect the pipeline infrastructure and detect the surrounding vegetation stress and ground change as well as temperature variation effectively. In addition, a digital twin and reality modeling approach was demonstrated for bridge inspection robot development and pilot training. This approach allows an integration of the virtual representation of bridge infrastructure, hardware (robots, sensors) and software (path planning, autonomous navigation and obstacle avoidance). Such a digital twin is promising to shorten the research and development cycle, reduce the cost and train the bridge inspector effectively in a more immerse environment.

Fig. 2 Dr. Constantinos Tsatsoulis and Dr. Genda Chen's team in a group photo taken at HyPoint

Fig. 3 Research Engineer Rafael Cardona Huerta demonstrating drone inspection capabilities

Zoughi Publishes Paper in IEEE Journal

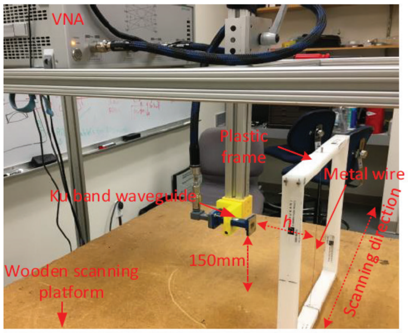


Fig. 1 Microwave scanning platform and specimen

Dr. Reza Zoughi published a paper titled "Influence of Antenna Pattern on Synthetic Aperture Radar Image Sidelobe Level in NDE Applications" in the Institute of Electrical and Electronics Engineers Journal. A typical microwave scanning test setup is shown in Fig. 1.

The influence of the antenna gain pattern on synthetic aperture radar (SAR) image sidelobe level is analyzed in this paper. The traditionally used antenna with a wide beamwidth results in relatively constant and large sidelobe level in SAR image. The presence of these sidelobes can mask adjacent weak indications which often necessitate windowing or implementation of other signal processing techniques in order to help reduce the effect of image sidelobes associated with strong target indications. Alternatively, using an antenna with a relatively narrow beamwidth provides for an inherent weighting function applied to the target spectrum, which is calculated within the SAR algorithm, along the cross-range direction, and this weighting function is directly related to the scanning antenna gain pattern properties. Consequently, an antenna with a relatively narrow beamwidth produces lower SAR image sidelobe level along the cross-range direction. Corroborating results from numerical simulations and measurements are provided to illustrate the impact of antenna gain pattern on SAR image sidelobe level.

Dr. ElGawady Leads Investigation on Bridge Collision Repair

Vehicle collisions with bridge supports or girders are the second leading cause of bridge collapse in the United States, with an average of three such collisions per day, according to researchers at Missouri S&T who are studying ways to improve bridge repair and cut costs for cities and states.

A railroad bridge in Kansas City, Missouri, is an example (see Fig 1). According to news reports, the Independence Avenue Bridge has been struck by trucks multiple times in recent months despite signs warning of height restrictions. Reports indicate the Kansas City Terminal Railway has spent $100,000 on signage and repairs over the past decade.

The Missouri S&T research project could reduce those types of repair costs for municipal and state governments and enhance bridge safety by finding more efficient repair methods.

Fig. 1 Truck-induced damage in bridge girder

“We are looking at two things in this project,” says lead researcher Dr. Mohamed ElGawady, Benavides Faculty Scholar and Professor of Civil, Architectural and Environmental Engineering at Missouri S&T. “First, we examine the remaining strength in a girder after impact. Second, we investigate how to repair the girders to recover their original strength.”

The research will address the lack of design tools that indicate how much load-bearing strength remains after impact, ElGawady says, adding that once repairs made, there is not much current research on the load-bearing capacity of the repairs.

ElGawady says there are two possibilities for repair – splicing together severed strands to repair damaged girders or making repairs using advanced materials such as fiber-reinforced polymers. ElGawady says the researchers will use materials that are readily available to entities needing to make repairs rather than researching new materials.

“We’re looking at very recent developments in ultra-high-performance concrete – state-of-the-art material that is emerging or on the market that they could use now,” he says.

ElGawady and his team at Missouri S&T are working with researchers at the University of Idaho to conduct numerical simulations that calculate damage from a vehicle hitting a bridge. Elgawady says they hope to secure an outdoor location where they could conduct actual tests with a mass hitting a girder.

The three-year research project is supported through $755,000 in pooled funding managed by the Missouri Department of Transportation. Other contributing states are Texas, Ohio, Mississippi, Idaho and Alaska, as well as the Federal Highway Administration. ElGawady says Mid-America Transportation Center has provided $85,000 in supplemental funding.

“During the COVID-19 pandemic and associated budget cuts, it was a really tense time for the states to dedicate money for this research,” says ElGawady. “That they did is another indication that this is a really serious issue.”

Original Version Posted January 25, 2021-Missouri S&T News and Events

Dr. Genda Chen Presented at 2021 Pipeline Research Conference

INSPIRE UTC Director, Dr. Genda Chen, attended the 2021 Pipeline Research Council International (PRCI) Virtual Research Exchange (VREX2021), which took place on March 2-5, 2021. The VREX2021 included plenary, keynote, panel, and networking sessions as well as concurrent technical sessions. Pre-recorded video presentations were played during the Conference. Dr. Chen's presentation on "Gas Leakage Detection with Hyperspectral Imagery-Based Vegetation Stress Indices," co-authored by Ph.D. student Pengfei Ma, is based on the study supported by USDOT/PHMSA's Competitive Academic Agreement Program under Contract #693JK31950005CAAP. Vegetations on the ground can work as sensors to detect the leakage in underground pipelines. The leakage stresses plants, thus yielding constituent changes in plant foliage. To separate the effect of gas leakage from other factors, plants are treated with methane gas, saline soil, heavy metal (HM) salt contaminated soil, and drought environment. The stress-induced compound change in abundance and molecular overtone can be represented by the light reflectance of leaf surfaces (see Fig. 1). The reflectance changes and thus spectral indices in hyperspectral images are identifiable in the visible light range and indicative of causative gas leakage.

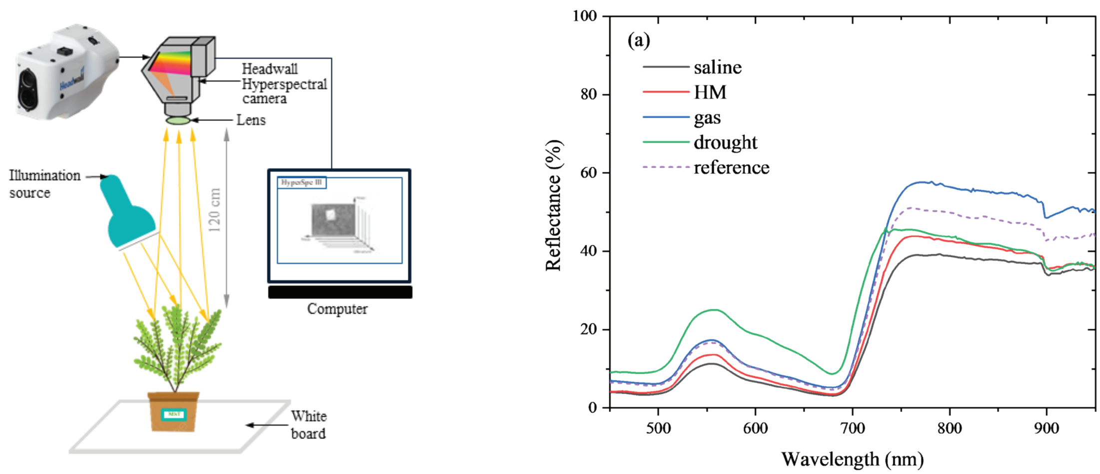


Fig. 1 Hyperspectral imaging setup and representative results

UTC Outstanding Student of the Year

Cadence Motley is currently pursuing a master's degree in Computer Science and Engineering at the University of Nevada Reno (UNR). Working in the UNR Advanced Robotics and Automation Laboratory, she designs and fabricates next-generation robots that can aid bridge inspectors in condition assessment and load rating. Cadence is also a teaching assistant for mechanical engineering seniors during their capstone design projects, and she volunteers for local STEM events. Most recently, Cadence was a judge for the statewide Nevada FIRST® Tech Challenge robotics championship for students in grades 7–12.

Outstanding Students of the Year are to recognize and honor the students supported by the UTC Program. Only U.S. citizens or permanent residents are qualified for this award. OST-R sponsors an annual awards banquet in collaboration with the Council of University Transportation Centers in January of 2021 in Washington, DC. Each Center can nominate or select one outstanding student of the year by the deadline established by the UTC Program Office. The Center must provide the student's information for inclusion in the Student of the Year Awards Program. Each participating Center must award its Student of the Year $1,000 and the costs for the student to attend the award ceremony at the TRB Annual Meeting.

Drs. Liujun Li & Haibin Zhang Join CII

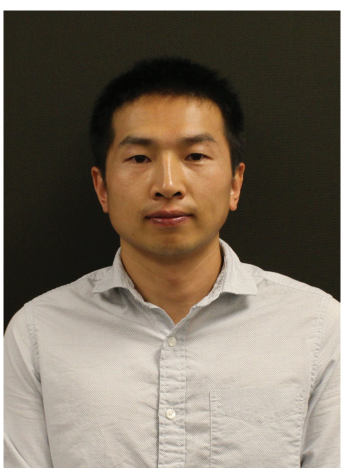
Dr. Liujun Li is an Associate Research Professor in the Department of Civil, Architectural and Environmental Engineering and the Center for Intelligent Infrastructure (CII) at Missouri University of Science and Technology (S&T).

Dr. Li received his post-doctoral training during 2012-2018 at the University of Illinois at Urbana-Champaign and the University of Georgia, focusing on research and development of machinery and robotics sensing, control and system integration as well as its associated data analysis and high-performance computing both at edge and cloud for precision farming operations and plant high-throughput phenotyping applications. Dr. Li received his B.S. Degree in Agricultural Automation from Hunan Agricultural University, MS. Degree in Materials Engineering and Ph.D. Degree in Mechatronics Engineering in 2011 from Central South University, China. In 2021, he joined Missouri S&T after about three years of leading autonomous robotics research and industrial AI development as principal investigator and engineer.

He has authored or co-authored over 30 technical research papers in system design, control and modeling, structure dynamics, material processing, remote sensing and proximity sensing, ground robot and unmanned aerial vehicle, image analysis and machine learning, earthquake engineering, precision agriculture and plant high-throughput phenotyping applications. Dr. Li is the Associate Editor of International Commission of Agricultural and Biosystems Engineering (CIGR) Journal and peer-reviewers of Computers and Electronics in Agriculture, Industry Robot, Advanced Shipping and Ocean Engineering, Meccanica, Transaction of ASABE, etc.

Research Interests:

Robotics sensing and control interface with machine learning and high-performance computing, communication and decision support systems, smart infrastructure, smart agricultural and environmental monitoring, multimodal sensing and image processing, deep learning, non-destructive evaluation, digital twin, intelligent cyber-physical system, big data analysis.



Dr. Haibin Zhang, Research Consultant at CII, received his B.S. Degree in civil engineering in July of 2009 from China Agricultural University. Upon completion of that degree, he was recommended for admission to Dalian University of Technology for Master's program in September of 2009. One year later, he enrolled a successive postgraduate and doctoral program for Ph.D. Degree on Disaster Prevention and Reduction Engineering and Protective Engineering. His doctoral research was focused on Piezoelectric Smart Aggregated-based Seismic Stress Monitoring and Model Updating for Reinforced Concrete (RC) structure. He obtained his doctoral degree in December of 2016 under the supervision of Dr. Jinping Ou (Academician of Chinese Academy of Engineering) and Dr. Shuang Hou. He joined Harbin Institute of Technology (Shenzhen) in March of 2017 and focused his research on the seismic damage monitoring of RC structure.

Dr. Zhang as a Research Consultant provides civil engineering support to interdisciplinary research agendas such as robotic platform, sensor integration, data analytics, bridge condition state assessment, and bridge management. In particular, his duties will include, but are not limited to,

1. Conduct specific research tasks in multi-hazard resilient designs of bridges and the use of inspection data for damage detection and bridge management.
2. Support proposal preparations, including literature review, data collection, and concept synthesis.
3. Support laboratory works for one (1) undergraduate and one (1) graduate students on various research tasks with exter nally sponsored projects.

Abbett Distinguished Lecture Presented by Dr. John W. van de Lindt

Resilience-Informed Guidance through Modeling and Interdisciplinary Field Studies

This presentation began with an overview of the Center for Risk-Based Community Resilience Planning's approach to merge engineering, social science/planning, and economics to form the Interdependent Networked Community Resilience Modeling Environment (IN-CORE). This includes learning from an interdisciplinary longitudinal field study beginning in 2016 to present for flooding in Lumberton, N.C., including challenges posed by a second hurricane and the pandemic on data collection and interpretation. The presentation closed with an illustrative example application of a community planning for tornado hazard and an example of resilience-informed policy guidance.

Dr. John W. van de Lindt is the Harold H. Short Endowed Chair Professor in the Department of Civil and Environmental Engineering at Colorado State University. Over the last two decades Dr. van de Lindt's research program has focused on performance-based engineering and test bed applications of building and other systems for earthquakes, hurricanes, tsunamis, tornadoes and floods. He is the co-director for the National Institute of Standards and Technology-funded Center of Excellence (COE) for Risk-Based Community Resilience Planning headquartered at Colorado State University. He has published more than 400 technical articles and reports including more than 200 journal papers, and currently serves as the Editor-in-Chief for the ASCE Journal of Structural Engineering.

About Abbett Distinguished Chair

In 2014, Dr. Genda Chen, professor of civil, architectural and environmental engineering at Missouri S&T, was named the Robert W. Abbett Distinguished Chair in Civil Engineering. This professorship was established in 2005 through a gift from the estate of Robert W. Abbett, a 1927 civil engineering graduate of the university. The faculty member chosen for this position must be an inspiring teacher from the civil engineering department and a leader in their field. Chen has been widely published for his pioneering research on structural behavior monitoring, inorganic enamel coating of steel rebar for enhanced corrosion resistance and bond strength in concrete, damping-enhanced strengthening strategy for performance-based earthquake engineering, and robot-assisted inspection and maintenance of bridges.

CII Develops UAV Training Facilities at Missouri S&T

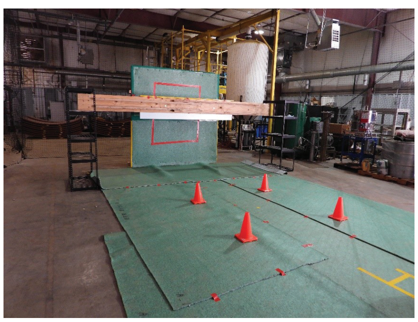


Fig. 1 Flight route planning in drone net

Fig. 2 Elios 2 drone flying in confined space

Since last month, the Center for Intelligent Infrastructure (CII) has begun drone pilot training. The training program is a comprehensive solution designed to develop all the skills that inspectors must have in order to fly drones and successfully acquire data (see Figs. 1 and 2).

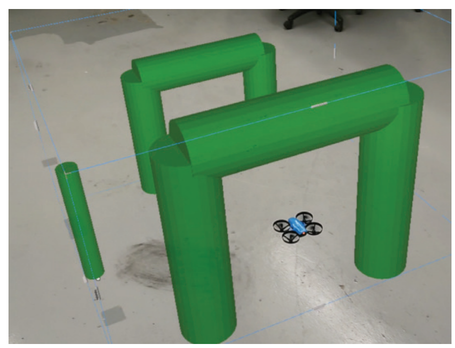


Fig. 3 Drone flying on an AR route

The UAV training program is divided into three sessions: (1) introduction, (2) flight simulator experience, and (3) flight control and operation. The first session will get trainees familiarized with flying concepts, FAA regulations and safety practices. The second session will help trainees become familiar with flight control in a virtual environment using a flight simulator. The third session will provide trainees with an opportunity to complete four different routes of flight exercise, including one practice with holograms to create Augmented Reality (AR) (see Fig. 3).

At the end of the training program, trainees will be able to conduct close-fly patterns avoiding collision and fly on first person view mode and control any mounted sensors to collect data on real bridges. In addition, the training center serves the INSPIRE UTC team for self training on the use of new techniques and new systems prior to conduct our field tests.

THE IMPORTANCE OF ACCOUNTING FOR SOIL EFFECTS IN RISK ASSESSMENTS OF BRIDGES SUBJECT TO SCOUR

Scour is one of the greatest risks facing our bridges today. When fast-flowing water or debris removes material around a bridge pier, the resulting scour hole leads to instabilities and vulnerabilities in the bridge structure. In fact, 60% of bridge failures in the United States have been found to be due to vulnerabilities associated with scour [1]. To better monitor the condition of and inform recommendations for risk mitigation measures for scour-susceptible bridges, ongoing measurements of bridge scour levels provides a way to continuously monitor the state of these bridges, for example, using the technologies to measure scour depth as developed through the INSPIRE UTC. These measurements can then be used to update the risk assessments of scoured bridges. However, to accurately do so, one must have accurate models of bridge scour available to properly assess and predict the behavior of scoured bridges.

Typical assessments of bridge performance under scour conditions involve simple removal of the soil modeled around the bridge foundation due to scour. These approaches, however, do not accurately account for soil effects in the assessments. They neglect to include the effects of soil stress history, where the soil that remains after a scour event is under a different stress state [2]. In this case, the strength characteristics of the soil need to be updated to reflect the new post-scour condition. In addition, analyses are often conducted based on simplified assumptions of structures located in homogeneous soil deposits, whereas layered deposits, e.g., soils with varying properties along the depth of the pile, are common [3]. Layered soil effects must be taken into account to accurately assess bridge performance.

In research conducted as part of the INSPIRE UTC, we have found that neglecting to take into account soil effects, in particular stress history and layered soil effects, can lead to unconservative assessments of bridge performance. In particular, it can lead to underestimation of pile axial displacements by up to 35%, and underestimation of exceeding safe bridge deck deflection thresholds by up to 25%, under static and dynamic loading conditions. To address this issue, we have developed a method, called the equivalent stress history and layered effects approach, abbreviated as ESHaLE, which enables one to capture the impact of soil stress history and layered soil effects in the risk assessment of scoured bridges [4].

In ESHaLE, the stress history effect is applied to the soil model first to obtain updated soil properties after scour. Next, the equivalent depths due to the layered effect are calculated based on the updated properties of the soil layer. This sequence is chosen such that the equivalent depth can be calculated based on the most up-to-date soil properties, including the stress history effects, enabling more realistic and accurate results. Outcomes are updated properties of the remaining soil, including updated effective vertical stress and adhesion factors, as well as equivalent layer depths and corresponding scour depths that account for the new scour conditions. A flowchart showing the overall ESHaLE process is shown below. Given the standard p-y, t-z, and q-z relations characterizing soil behavior in models capturing soil-structure interaction, the results are the p-y, t-z, and q-z parameters, e.g., ultimate soil resistance, determined based on the combined updated soil properties and equivalent depths. Details of the ESHaLE method are found in [4]. Now, we show results from this study demonstrating the importance of accounting for soil effects in risk assessments of bridges subject to scour. We begin with a static load case, where a vertical load is applied at the pile head under varying scour depth conditions. We compare the maximum axial displacement observed based on three soil models: the newly developed equivalent stress history and layered effects (ESHaLE) approach, considering the layered effect only (LEO), and the traditional unmodified (UMD) model. From the plot, the difference in axial displacements anticipated based on analyses using the different models is significant, with the values obtained using the non-ESHaLE models significantly underestimating potential pile axial displacements. The degree of underestimation also increases as the scour depth increases, showing the importance of considering both stress history and layered soil effects when assessing performance of scoured bridges. Now, under a dynamic loading scenario, we consider deck deflection values as a measure of bridge performance. The plot

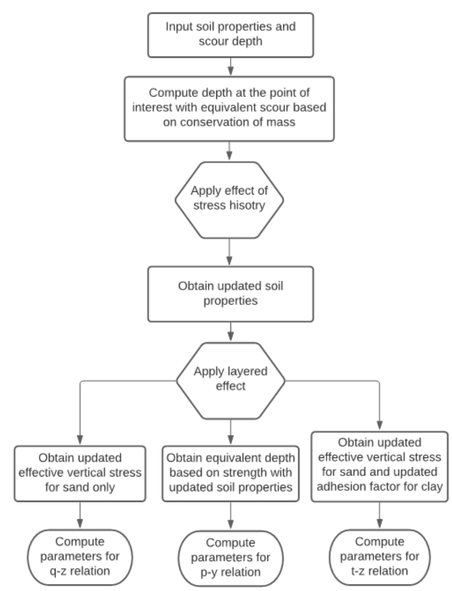


Fig. 1 Neglecting to take into account soil effects, in particular stress history and layered soil effects, can lead to unconservative assessments of bridge performance

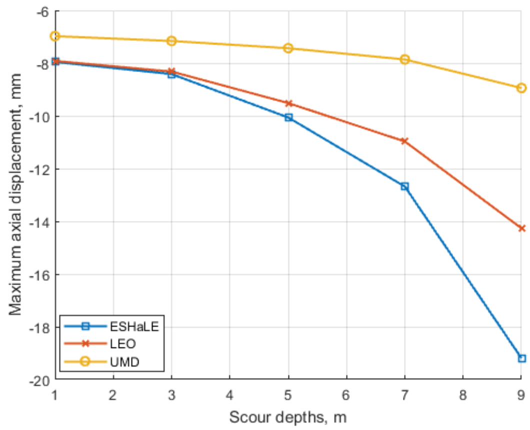


Fig. 2 Effect of scour depth on axial displacement

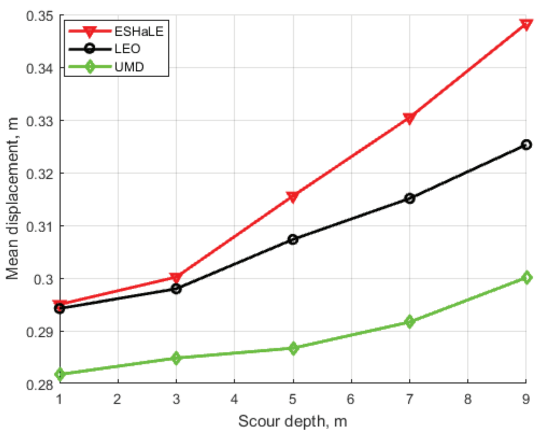


Fig. 3 Mean displacement change with scour depth

shows the differences in mean displacement values estimated under varying scour depth conditions from the three soil models. Again, not considering stress history and layered soil effects, i.e., using the non-ESHaLE models, significantly underestimates deck deflections, with the difference increasing as scour depth increases. Considering a bridge deflection limit beyond the serviceability limit and a L/250 deflection threshold [5], these values correspond with increases of 25% and 46% likelihood that the deflection of the deck will exceed the threshold in comparison with the value calculated using the LEO and UMD models, respectively. The ESHaLE approach takes into account both stress history and layered soil effects in the assessment of scoured bridges. When integrating measurements of scour depth with bridge models and analysis, it enables one to be able to accurately assess and quantify risks associated with bridge scour.

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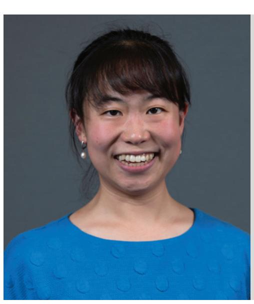
ABOUT THIS PROJECT

Led by Dr. Iris Tien in the School of Civil and Environmental Engineering at the Georgia Institute of Technology, the Bridge Resilience Assessment with INSPIRE Data project is part of the INSPIRE UTC research program. The aim is to create novel methods to utilize bridge inspection data to update assessments of bridge risk. For more information on this project, please contact Dr. Tien at itien@ce.gatech.edu or (404) 894-8269.



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ASSISTIVE INTELLIGENCE: A COLLABORATION BETWEEN HUMAN AND ARTIFICIAL INTELLIGENCE FOR SEGMENTING BRIDGE ELEMENTS FROM INSPECTION VIDEO DATA

The U.S. National Bridge Inventory has over 600,000 highway bridges. 39% of these bridges are over 50 years old, and almost 9% are structurally deficient requiring significant repair [1]. Rehabilitation, maintenance, and rebuilding efforts are necessary for preserving the transportation infrastructure throughout the United States. For example, National Bridge Inspection Standards require that bridges be inspected every two years to ensure no cracks, rust, or other damage [2]. The conventional bridge inspection requires a crew of two inspectors, heavy equipment with a lifting capability, access to dangerous elevated structures, and the closure of roads during the time of inspection. These make the bridge inspection one of the most dangerous and costly operations in the state Departments of Transportation. Results of the visual inspection are inaccurate and vary largely among different inspectors although the image-reference approach is developed to guide the inspection [3]. It is desired to have a system that assists bridge engineers in analyzing inspection video data efficiently and effectively. Therefore, this study developed a cyber-physical system (CPS) for this purpose. The cyber part of the system digitally profiles the bridge conditions by detecting and segmenting important bridge elements, which facilitate the management of the bridge in the physical world. This CPS provides a data-driven decision support for the preservation of the bridge.

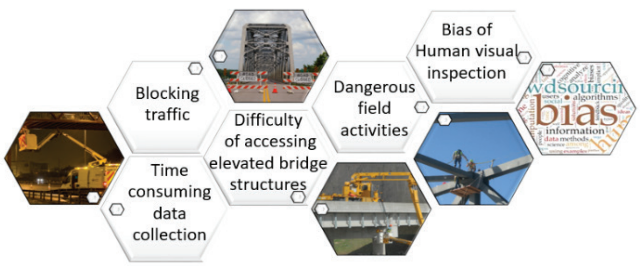


Fig. 1 Challenges in infrastructure inspection

The developed CPS aims to engage inspectors in the development of the video data analysis tool. This creates an assistive intelligence model for detecting and segmenting multiclass structural elements from bridge inspection videos captured by an aerial inspection platform. The achieved job efficiency and the quality of the model let inspectors truly benefit from the technology advancement in their jobs. The assistive intelligence model is not an artificial intelligence model isolated from inspectors. Instead, inspectors provide their expertise to guide the development of the model, which assures the network quickly converges to a satisfactory tool for assisting themselves in analyzing the videos of any intended bridge of inspection.

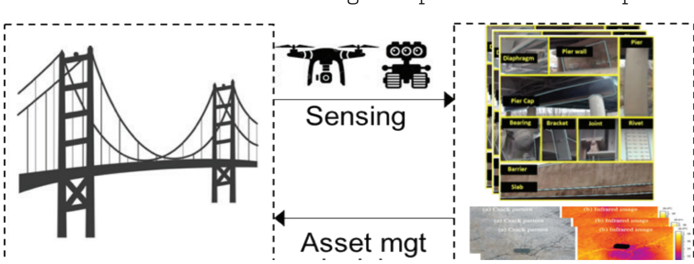


Fig. 2 Cyber Physical System for bridge inspection

The developed model consists of three major components, (i) a quick transfer of an existing deep learning network to the task of detecting and segmenting multiclass structural elements from bridge inspection videos, (ii) the use of a lightweight temporal coherence analysis to recover false negatives and identify weakness that the network can learn to improve, and (iii) a semi-supervised self-training (S3T) algorithm that keeps human-in-the-loop to iteratively boost up the performance of the deep neural network.

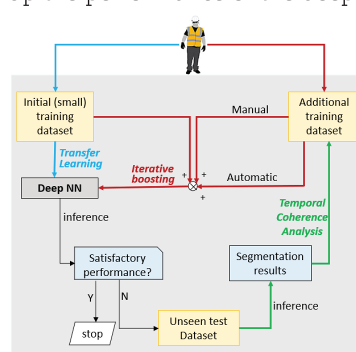


Fig. 3 Overview of the proposed approach

To achieve the goal of bridge inspection using the developed assistive intelligence model, an inspector creates a very small initial training dataset to initiate the training procedure of the model. With this small dataset and through transfer learning, a pre-trained deep neural network obtains the basic capability in multiclass bridge element detection and segmentation. Then, this trained model is applied to an unlabeled testing dataset to generate detection and segmentation results. If the result does not reach

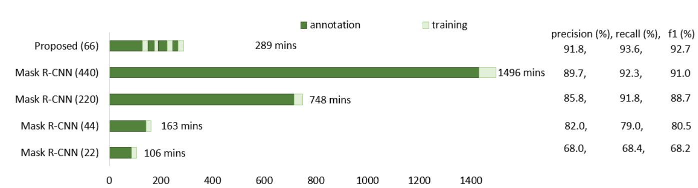


Fig. 4 A comparison of model development time and model performance

the satisfactory level, temporal coherence analysis helps identify some hard samples and recommend additional training dataset to train the model iteratively using the semi-supervised self-training method with human-in-the-loop, for improving the model.

The proposed method has been proved to be very cost-effective. It uses only 66 inspector-annotated images to develop the model within 5 hours and achieves a remarkably high performance of 91.8% precision and 93.6% recall. The traditional mask CNN takes 440 inspector-annotated images and 25 hours to annotate and train the model. The precision and recall achieved by the mask CNN are below those of the proposed method. This signifies that the proposed method can give a huge performance gain in a noticeably shorter time.

	Work time (min)	Accuracy (%)
w/o the AI tool	65	100
w/ the AI tool	0.27	93.7
change	↓99.5%	↓6.3%

Fig. 5 Benefit of using the tool

To understand the helpfulness of the proposed tool in inspection image data analysis, an experiment was conducted on a small-scale dataset of 20 images to detect and segment bridge elements. It is found that without the developed assistive intelligence tool an inspector takes 65 minutes to analyze the data. With the assistive intelligence tool, it takes only 0.27 minutes.

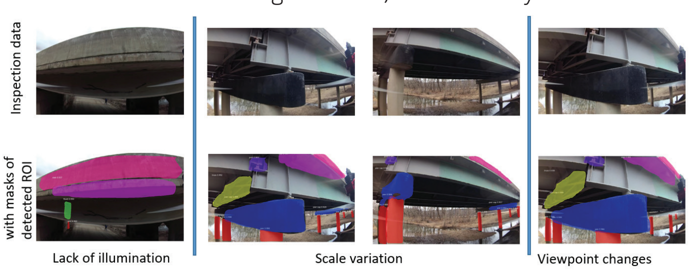


Fig. 6 Illustrative examples of the segmentation generated by the proposed method

This indicates that the developed method reduces the work time by 99.5%. This experiment did not consider human factors such as human bias, fatigue, loss of attention, and so on. Not to mention that such human related issues can further diminish the performance of the completely manual approach.

The developed method successfully segmented bridge elements in different challenging situations, such as lack of illumination, scale variation, or viewpoint changes. Fig. 6 contains a few of such examples.

This study developed an assistive intelligence model that keeps human-in-the-loop, which is an effective method to leverage human intelligence into the artificial intelligence algorithms. That is, algorithms provide humans with its performance so that humans can figure out the weakness and provide inputs to the algorithms for further improvement. To develop this method, this study uses transfer learning, self-training, and active learning to best utilize a small amount of training data to adapt to a new task. In a nutshell, model adaptability and the collaboration between artificial intelligence and human experts were integrated together as a solution for developing assistive intelligence that takes care of time-consuming, boring tasks and let humans focus on knowledge-intensive tasks. This will be a new style of work for future bridge professionals.

References

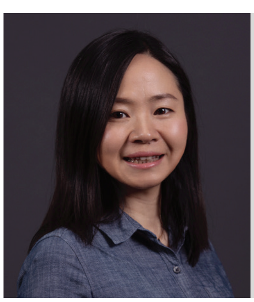
[1] ASCE (2017). Infrastructure Report Card. Technicalreport, American Society of Civil Engineers. URL https://www.infrastructurereportcard.org/wp-content/uploads/2016/10/2017-Infrastructure-Report-Card.pdf.

[2] Henderson G. (2017). Highway Bridge Inspections. URL https://www.transportation.gov/content/highway-bridge-inspections.

[3] AASHTO (2019). Manual for Bridge Element Inspection, 2 ed.

ABOUT THIS PROJECT

Led by Dr. Ruwen Qin, formerly Associate Professor of Engineering Management & Systems Engineering at Missouri University of Science & Technology, currently Associate Professor of Civil Engineering at Stony Brook University, the project "A Training Framework for Robotic Operation and Image Analysis for Decision-Making in Bridge Inspection and Preservation" is part of the INSPIRE UTC Program. For more information, please contact Dr. Genda Chen, Director of INSPIRE UTC.



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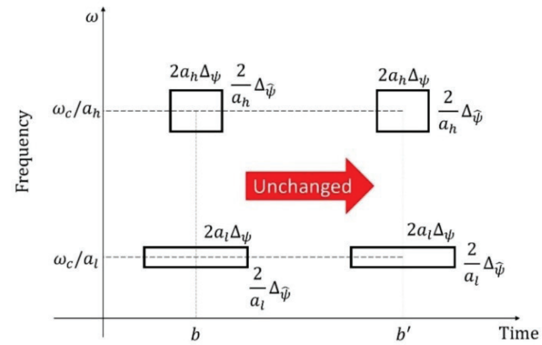
SYNCHRO-SQUEEZED ADAPTIVE WAVELET ANALYSIS FOR EFFECTIVE EXTRACTION OF FEATURES FROM NONSTATIONARY DATA SERIES

This article presents a data analytics tool that was recently developed to extract engineering features from a nonstationary data series. Referred to as synchro-squeezed adaptive wavelet transform (SSAWT), the analytics tool is based on an average of overlapped short-time wavelet transforms with optimized time-varying resolution in a synchro-squeezed time-frequency representation. The time-frequency resolution is automatically updated following a simplified procedure to determine optimal wavelet parameters over time. The SSAWT was applied to the impact echo responses experimentally recorded from a 60"×36"×7.25" concrete slab. The improvement in time-frequency resolution and corresponding frequency spectra led to more successful detections of deep/shallow/no delamination from 40 sets of experimental data.

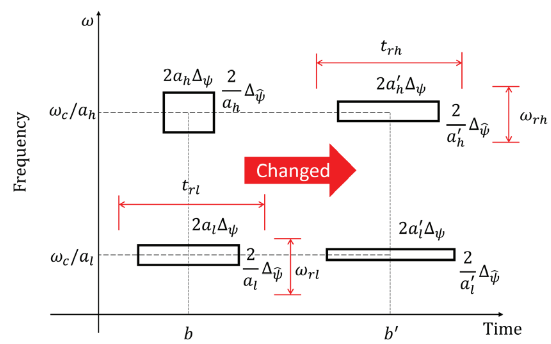
Continuous wavelet transform (CWT) has been widely used to provide variable frequency resolution at each time by introducing a scaling factor, a ϵ (a_l,a_h), and a shifting factor, b or b', to a mother wavelet. As illustrated in Fig. 1(a), the range of frequency resolution at every time remains the same. Here, ω_c represents the center frequency of the mother wavelet; Δ_ψ and $\Delta_{\hat{\psi}}$ are the radii of the mother wavelet and its Fourier transform, respectively. The longer the side of a rectangle in Fig. 1(a), the lower the resolution the illustrative rectangle represents. For strongly nonstationary signals, the same range of frequency resolution over time may be inadequate for the detection of multiple defects manifested through different physical processes in engineering applications.

To enable the selectivity of time and frequency resolution over time, adaptive wavelet transform (AWT) introduces a time-varying center frequency ω_c and a time-varying scaling factor in the mother wavelet. AWT was formulated by defining and averaging overlapped short-time wavelet transforms with different sizes (durations) of the time windows. The introduction of two time parameters (the shifting factor and the window duration) allows a modification of time and frequency resolution over time for a desirable time-frequency representation of a signal as schematically illustrated in Fig. 1(b). Like the CWT, the time and frequency resolution of the AWT can be changed at any time. Unlike the CWT, the scaling factor and the center frequency introduced in the AWT are time-dependent, resulting in selectable time and frequency resolution range over time. Note that $\omega_c/a_l=\omega'_c/a'_l$ and $\omega_c/a_h=\omega'_c/a'_h$. Here, ω'_c, a'_l, and a'_h are proportional to ω_c, a_l, and a_h, respectively, at a different time. In doing so, the AWT is adaptive to the change in signal amplitude only.

Both CWT and AWT gives dispersive and blurry scalograms around ridgelines in time-frequency domain. As such, synchro-squeezed AWT (SSAWT) was recently developed to acquire a more accurate time-frequency representation with sharpened ridgelines.



(a) Continuous wavelet transformation (CWT)



(b) Adaptive wavelet transformation (AWT)

Fig. 1 Illustration of time-frequency resolution

The efficacy of the SSAWT was tested for the interpretation of impact echo (IE) test signals from a 60"×36"×7.25" concrete slab with six pre-embedded artificial defects (A to F) as summarized in Table 1. The defects were pre-embedded in the slab to simulate conditions of shallow and deep delamination.

Shallow delamination is associated with the long-duration flexural vibration of plate-like structures or long-duration surface wave reflection from the boundaries of finite-dimension structures under impact loads. The fundamental frequency of the flexural mode vibration can be related to the depth and width of delamination by a semi-analytical equation developed for rectangular defects.

Deep and no delamination are associated with the body wave reflection at delamination or at the bottom edge of the slab. The corresponding resonant frequency can be related to the delamination depth or slab thickness. The theoretical frequencies associated with the embedded defects are calculated and given in Table 1.

Table 1 Artificial defect properties and theoretical frequencies

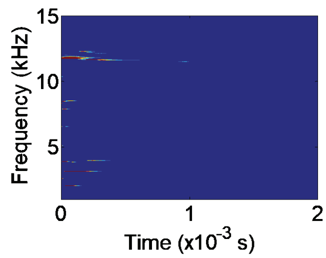
Defect	Plan Dimension (in. × in.)	Thickness (in.)	Embedment Depth (in.)	Material	Frequency (Hz)
A	12.0×11.5	-	6.250 (deep)	Cardboard	9,677
B	12.0×11.5	-	1.875 (shallow)	Cardboard	1,732
C	6.0×5.0	1.000	5.250 (deep)	Foam	11,520
D	6.0×5.0	1.000	2.500 (shallow)	Foam	4,928
E	10.0×6.5	-	6.250 (deep)	Cardboard	9,677
F	10.0×6.5	-	1.875 (shallow)	Cardboard	3,676

A portable seismic property analyzer with one source and two receivers was used to generate with the impact source, sample at 390 kHz and record IE responses in the concrete slab. A total of 40 measurements were taken with respect to the locations of six defects (A to F). Each measurement was obtained from the near receiver and defined in the middle of the source and near receiver spacing at 10 cm.

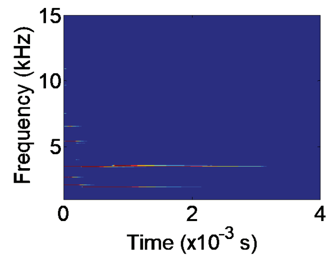
Fig. 2 presents representative SSAWT scalograms for deep (measurement 22), shallow (23), and no (27) delamination. It can be seen from Fig. 2 that the time duration and characteristic frequencies of the signals under various defect conditions are visually discernable in this application example.

SSAWT is robust and accurate in the detection of concrete delamination from IE responses. Due to mixed frequency characteristics associated with deep, shallow and no delamination conditions, high time resolution is needed to exclude shallow delamination from the other two while high frequency resolution is generally required to identify either deep delamination depth or slab thickness. Only two out of 40 measured IE responses led to falsely identified delamination conditions. The two exception locations were on the edge of pre-embedded defects. The detection error was less than 1.5% in deep delamination depth and 5% in slab thickness.

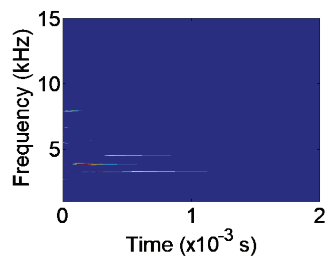
In closure, SSAWT is optimized in terms of center frequencies, scaling factors, and window lengths over time based on the CWT ridgeline thickness to derive optimum time-varying resolution of interest.



(a) Deep delamination



(b) Shallow delamination



(c) No delamination

Fig. 2 SSAWT scalograms for deep (measurement 22), shallow (23), and no (27) delamination

References

[1] Qu, Hongya, Li, Tiantian, and Chen, Genda. (2018). Adaptive Wavelet Transform: Definition, Parameter Optimization Algorithms, and Applications for Concrete Delamination Detection from Impact Echo Responses. Structural Health Monitoring 1-18. URL https://doi.org/10.1177/1475921718776200.
[2] Qu, Hongya, Li, Tiantian, and Chen, Genda. (2019). Synchro-squeezed Adaptive Wavelet Transform with Optimum Parameters for Arbitrary Time Series. Mechanical Systems and Signal Processing 114, 366-377.

ABOUT THIS PROJECT

Led by Dr. Genda Chen, Professor and Abbett Distinguished Chair at Missouri S&T, this study was supported by the U.S. National Science Foundation under award No. CMMI1538416. For more information on this project, please contact Dr. Chen at inspire-utc@mst.edu or (573) 341-6114.

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EDUCATIONAL MODULE SERIES

ROBOTIC INSPECTION OF INFRASTRUCTURE

BY JIZHONG XIAO FROM CITY COLLEGE OF NEW YORK (CCNY)

The senior design course (EE598.66, EE598.67) at CCNY is a mandated two semester sequence for senior undergraduate students in EE/ME/CS departments. Dr. Jizhong Xiao offers robotics track and recruits seniors from different majors to form multi-disciplinary teams working on Robotic Inspection of Infrastructure every year starting from Fall semester. In the first semester, the general lectures taught by a dedicated instructor will introduce market research, project management, intellectual property (IP), entrepreneurship, etc. The faculty mentor of each senior design track offers special technical lectures for the students in their tracks. The lectures in robotics track cover such topics as history of robotics, definition of robots, homogenous representation, mobile robot locomotion, motors and control, sensors, actuators, robotic navigation, vision algorithms, special robots for inspection, market needs for inspection of infrastructure, and introduction to INSPIRE projects. Under the guidance of the faculty mentor, the undergraduate seniors will read technical papers, form teams to survey the state-of-the-art technologies, perform patent searches, conduct marketing analyses, and write project proposals that include market needs, problem statements, design ideas, a reasonable budget, a management plan with milestones, and a business plan. The EE/ME/CS students are encouraged to form multidisciplinary teams and work collaboratively to contribute their different expertise in the projects. The faculty mentor will review the proposals and give senior design students feedback to refine their projects. In the second semester, the student teams are expected to implement design ideas, draw CAD models, evaluate different design options, fabricate components, assemble prototypes, and perform system integration and experimental testing. Students will gain hands-on experience in applying their knowledge to produce a working robot prototype to solve real world problems. At the end of spring semester, the student teams will showcase their senior design projects to faculty mentors, student peers and industry judges at industry day in May and receive grades. The student teams with innovative design and excellent working prototypes will receive awards and are encouraged to participate various entrepreneur competitions.

COMPUTER SCIENCE SEMINARS AT MISSOURI S&T

COORDINATED BY DR. SAJAL DAS

As part of the 150th anniversary celebration on the establishment of Missouri S&T campus, the Department of Computer Science sponsors a weekly seminar series presented by a combination of department faculty, graduate students and external speakers in Fall 2020 and Spring 2021. Following is a list of Spring 2021 seminar topics and speakers. An archive of departmental seminars can be found at https://cs.mst.edu/seminars-colloquia/archived-seminars/.

Computer Science Seminars and Colloquia	
Project	**Speaker**
AI FOR SOCIAL IMPACT: RESULTS FROM MULTIAGENT REASONING AND LEARNING IN THE REAL WORLD	BY DR. MILIND TAMBE FROM HARVARD UNIVERSITY
INDOOR NETWORKS WITH A 6TH SENSE	BY DR. KLAUS DOPPLER FROM NOKIA BELL LABS
PHYSICAL LAYER SECURITY IN WIRELESS NETWORKS	BY DR. VINCENT POOR FROM PRINCETON UNIVERSITY (NAE MEMBER)
FACING THE CHALLENGES OF INDUSTRY 4.0	BY DR. GIUSEPPE ANASTASI AND DR. CARLO VALLATI FROM UNIVERSITY OF PISA, ITALY
BY THE PEOPLE, FOR THE PEOPLE: WHAT SCIENCE TELLS US ABOUT LIBERAL DEMOCRACY	BY DR. ALEX (SANDY) PENTLAND FROM MIT (NAE MEMBER)
SECURITY OF CYBER-PHYSICAL SYSTEMS	BY DR. P. R. KUMAR FROM TEXAS A&M UNIVERSITY (NAE MEMBER)
LOW POWER WIDE-AREA WIRELESS INTERNET OF THINGS WITH LORA/LORAWAN	BY DR. DIRK PESCH FROM UNIVERSITY COLLEGE CORK, IRELAND
FAIR, STRATEGIC AND TRUSTWORTHY SOCIO-TECHNICAL SYSTEMS	BY DR. SID NADENDLA FROM MISSOURI S&T
COMPUTATION BEHAVIOUR ANALYSIS FOR USER-CENTERED HUMAN MACHINE SYSTEMS WITHIN SMART ENVIRONMENTS	BY DR. LUKE CHEN FROM ULSTER UNIVERSITY, UK
INTELLIGENCE FOR CELLULAR NETWORKS	BY DR. VIJAY GOPALAKRISHNAN FROM AT&T RESEARCH
CLUSTERING FROM PAIRED OBSERVATIONS	BY DR. CLAYTON SCOTT FROM UNIVERSITY OF MICHIGAN
TOWARDS SMARTER TRANSPORTATION: USING TRAJECTORY DATA FOR VEHICLE ROUTING	BY DR. CHRISTIAN JENSEN FROM AALBORG UNIVERSITY, DENMARK
NEW RESULTS ON THE MIN-GAP SCHEDULING PROBLEM	BY DR. FEI LI FROM GEORGE MASON UNIVERSITY
PERSPECTIVES ON FOUNDATIONAL AND USE INSPIRED RESEARCH AT NATIONAL SCIENCE FOUNDATION - CYBER PHSICAL SYSTEMS AND SMART AND CONNECTED COMMUNITIES	BY DR. DAVID CORMAN FROM THE NATIONAL SCIENCE FOUNDATION

GEORGIA TECH PH.D. STUDENT YIJIAN ZHANG STARTS TO WORK AT BRIDGE CONSULTING FIRM

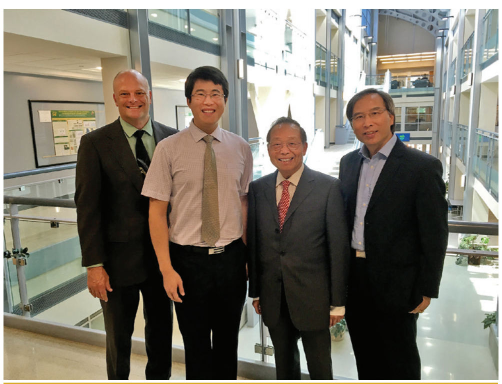
Yijian Zhang will graduate in May 2021 with his Ph.D. degree from the Georgia Institute of Technology. Mr. Zhang's doctoral thesis work has been supported by the INSPIRE UTC as part of Dr. Iris Tien's research group. Dr. Tien is an investigator in the INSPIRE research program.

Mr. Zhang utilized collected inspection data to evaluate the structural conditions of bridges through novel modeling approaches for structural risk analysis. Of particular interest was the aging of bridge structural components due to natural degradation events, such as corrosion and scour, and assessing of the impacts of these mechanisms on bridge risk. The Ph.D. work completed by Mr. Zhang can be summarized into the following six areas:

1. Exploration of failure modes of aging structural columns considering the impacts of measured corrosion
2. Methodology to update fragility assessment through Bayesian inference in bridge risk assessment
3. Methodologies to assess structural reliability accounting for physical phenomena after scour events, including the impacts of soil stress history, scour hole dimensions, and layered soils effects
4. Investigation of the influence of measured non-uniform scour on bridge responses
5. Fragility assessment of bridges utilizing both scour and corrosion inspection data
6. Robustness and accuracy of analyzing frame elements with a softening material constitutive behavior

Upon graduation, Mr. Zhang will join CHI Consulting Engineers, a bridge consulting firm in New Jersey. His primary duties will include finite element analysis, seismic and wind design, vibration mitigation, and structural health monitoring. Mr. Zhang will bring his experience with INSPIRE UTC and his doctoral training into practice in his new position.

STEM TEACHING SCHOLARS PROGRAM INSPIRES WORKFORCE DEVELOPMENT



(LEFT TO RIGHT) DRS. JOEL BURKEN, YI BAO, FRANKLIN CHENG, AND GENDA CHEN

One of the INSPIRE UTC workforce development goals is to increase STEM teaching scholars in infrastructure preservation and resiliency, who will inject new bloods in the U.S. academic system. With the fast approaching of the fourth industrial revolution, our current academic system becomes increasingly obsolete in producing next generation workforce for unmet market/industrial demands for intelligent infrastructure, autonomous/robotic systems, high-speed internet of things, data science and engineering, and artificial intelligence.

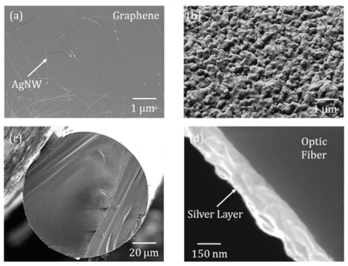
Preparing and training our Ph.D. graduates to become academic leaders is an effective way to increase the needed workforce in the wake of the fourth industrial revolution. While provided with ample research training through Ph.D. degree programs related to the INSPIRE UTC projects, graduate students are often not given the opportunity to develop their teaching effectiveness and independent lecture experience (e.g., syllabus, lecture notes, homework, exams, presentations, communication and interaction with students, etc.) beyond serving as a teaching assistant or providing an occasional lecture. Teacher training lacks behind in STEM education. In the Department of Civil, Architectural, and Environmental Engineering at Missouri University of Science and Technology, Curators' Distinguished Professor Emeritus Dr. Franklin Cheng has been one of lifelong academic leaders in the U.S. and looked to continue his legacy by supporting teaching effectiveness training for promising Ph.D. candidates (or recent graduates) under the Franklin Y. and Pi-Yu C Cheng Teaching Scholars Program (read details on Page 22 in *The Bridge* at https://scholarsmine.mst.edu/bridge/6/). Effective 2016, the Teaching Scholars Program has been a key academic and professional development opportunity that allows doctoral candidates (or recipients) within the department to teach a course twice in their area of expertise. Since then, the Program has been instrumental in training next-generation workforce in the theme area of the INSPIRE UTC. To date, six Ph.D. students (see table) have completed their teacher training through the Program. The inaugural teaching scholar, Dr. Yi Bao (see photo), is currently an assistant professor at Stevens Institute of Technology, New Jersey, USA.

DRS. FRANKLIN Y. AND PI-YU C. CHENG TEACHING SCHOLAR AWARDS

Year	Awardee	Ph.D. Dissertation Advisor
2016 – 2017	Yi Bao	Dr. Genda Chen, Professor and Abbett Distinguished Chair
2017 – 2018	Hayder Alghazali	Dr. John Myers, Professor
2018 – 2019	Mohanad Abdulazeez	Dr. Mohamed ElGawady, Professor and Benavides Scholar
2019 – 2020	Chuanrui Guo	Dr. Genda Chen, Professor and Abbett Distinguished Chair
2020 – 2021	Yi Zhao	Dr. Guirong Yan, Associate Professor

INSPIRE WEBINARS

UPCOMING WEBINARS

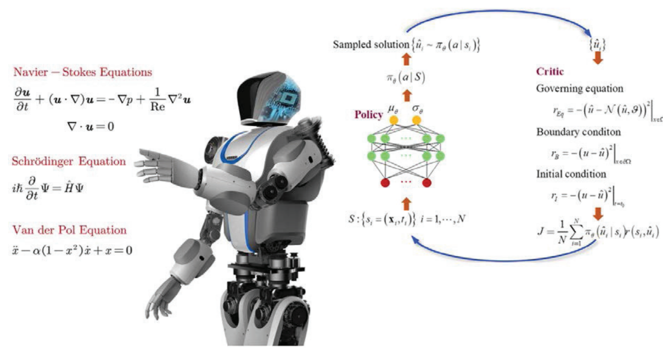


FIBER OPTIC SENSOR BASED CORROSION ASSESSMENT IN REINFORCED CONCRETE BRIDGE ELEMENTS AND METAL PIPELINES

Present: June 16, 2021, 10:00AM-11:00AM (CST)
Speaker: **Dr. Genda Chen**
Professor and Robert W. Abbett Distinguished Chair in Civil Engineering, Director of INSPIRE UTC, and Director of CII
Register: **inspire-utc.mst.edu/webinars**

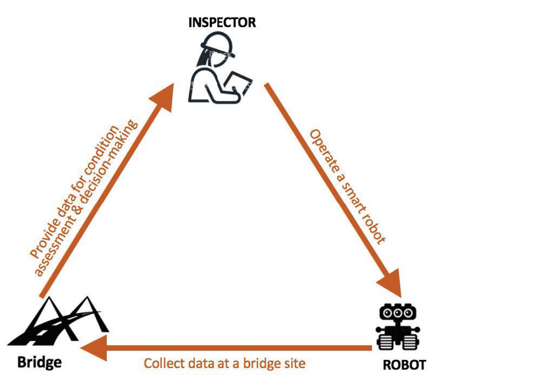
In this 50-minute lecture, the fundamental concepts of fiber optic sensors for both distributed and point corrosion measurements are reviewed. For the distributed monitoring of a line bridge component such as steel reinforced girders, Brillouin scattering and fiber Bragg gratings (FBG) can be coupled to measure both temperature and radial strain as an indirect indicator of corrosion process. For the point monitoring of steel structures, long period fiber gratings (LPFG) are specially designed for a direct measurement of mass loss or the loss in cross sectional area of the component. In particular, a Fe-C coated LPFG sensor is introduced for corrosion induced mass loss measurement when Fe-C materials are comparative to the parent steel component to be monitored. The sensing system operates on the principle of LPFG that is responsive to not only thermal and mechanical deformation, but also the change in refractive index of any medium surrounding the optical fiber. Fabrication process of the LPFG is demonstrated through the CO2 laser aided fiber grating system. To enable mass loss measurement, a low pressure chemical vapor deposition (LPCVD) system is introduced to synthesize a graphene/silver nanowire composite film as flexible transparent electrode for the electroplating of a thin Fe-C layer on the curve surface of a LPFG sensor. An integrated sensing package is illustrated for corrosion monitoring and simultaneous strain and temperature measurement. Two bare LPFGs, three Fe-C coated LPFG sensors are multiplexed and deployed inside three miniature, coaxial steel tubes to measure critical mass losses through the penetration of tube walls and their corresponding corrosion rates in the life cycle of an instrumented steel component. The integrated package can be utilized for in-situ deterioration detection in reinforced concrete and steel structures. Assisted by a permanent magnet in pipeline monitoring, both FBG and LPFG sensors are combined with an extrinsic Fabry-Perot interferometer (EFPI) to measure both internal and external thickness reductions without impacting the operation of the pipeline.

RECENT WEBINARS



ARTIFICIAL INTELLIGENCE-EMPOWERED CIVIL ENGINEER

Presented: December 8, 2020
Speaker: **Dr. Hui Li**
Changjiang Scholar and Professor in Civil Engineering and Mechanics
Harbin Institute of Technology; Harbin, China



HUMAN-ROBOT COLLABORATION FOR EFFECTIVE BRIDGE INSPECTION IN THE ARTIFICIAL INTELLIGENCE ERA

Presented: March 23, 2021
Speaker: **Dr. Ruwen Qin**
Associate Professor of Civil Engineering
Stoney Brook University

RECENT KEYNOTE/INVITED PRESENTATIONS

- **“Gas Leakage Detection with Hyperspectral Imagery-Based Vegetation Stress Indices”** VIRTUAL Research Symposium, VREX, 2021. Pipeline Research Council International (PRCI) Virtual Research Exchange (VREX2021), March 2021, presented by Dr. Genda Chen and Pengfei Ma (invited).
- **"Robot-assisted Bridge Inspection and Maintenance"** CWRU Civil and Environmental Engineering Department Seminar, March 2021, presented by Dr. Genda Chen (invited).
- **"Robotic Platform for Autonomous Bridge Inspection and Maintenance"** International Conference on Unmanned Aerial Vehicles, Remote Control Vehicles and Remotely Operated Vehicles for Onshore, Offshore and Subsea Asset and System Integrity: DRONES & ROVS, London, UK, February 2021, presented by Dr. Genda Chen (keynote).

WEBINAR ARCHIVES

2021

Human-Robot Collaboration for Effective Bridge Inspection in the Artificial Intelligence Era
By Dr. Ruwen Qin, Stony Broook University, March 23, 2021

2020

Artificial Intelligence-Empowered Civil Engineer
By Dr. Hui Li, Harbin Institute of Technology; Harbin, China, December 8, 2020

UAV-Enabled Measurement for Spatial Magnetic Field of Smart Rocks in Bridge Scour Monitoring
By Dr. Genda Chen, Missouri S&T, September 14, 2020

Mobile Manipulating Drones
By Dr. Paul Oh, University of Nevada, Las Vegas, June 17, 2020

Non-Contact Air-Coupled Sensing for Rapid Evaluation of Bridge Decks
By Dr. Jinying Zhu, University of Nebraska, Lincoln, March 12, 2020

2019

Data to Risk-Informed Decisions Through Bridge Model Updating
By Dr. Iris Tien, Georgia Institute of Technology, September 25, 2019

A Performance-Based Approach for Loading Definition of Heavy Vehicle Impact Events
By Dr. Anil Agrawal, The City College of New York, June 5, 2019

Battery-Free Wireless Strain Measurement Using an Antenna Sensor
By Dr. Yang Wang, Georgia Institute of Technology, March 6, 2019

Assistive Intelligence (AI): Intelligent Data Analytics Algorithms to Assist Human Experts
By Dr. Zhaozheng Yin, Missouri S&T, January 30, 2019

VIEW COMPLETE LIST OF WEBINARS
scholarsmine.mst.edu/inspire_webinars

Kaleidoscope Discovery Center Holds Robotics Competitions

Since November 2020, the Kaleidoscope has actively supported robotics and engineering education at four sites consistently reaching 50 students per week while adhering to local COVID protocols. In addition, two virtual robotics sessions for 1st -3rd grade students were conducted in February and March using Zoom meetings.

From November 2020 to March 31, 2021, the Kaleidoscope supported the Dent R3 robotics team, the Newburg robotics program, and the Rolla program at the Kaleidoscope Discovery Center on a weekly basis. Teams have filled for the targeted First Lego League (FLL) Discover and FLL Challenge as per the scope of the INSPIRE UTC grant, with seven teams completing the full year in the FLL Explore group.

The annual Kaleidoscope Robotics Expo was held on Saturday, April 10, with teams attending with their pods at separate times in order to reduce the potential of virus spread. Pictures of the event and the comments that the judges made about the teams projects follow:

The Captains – "Heart-Pumping Sports"
Wow! The judges loved the many indoor exercise options! Ice skating, soccer, tennis, rock climbing, cricket and a water park! Just Wow. Everything had so much color and felt like you did a good job of deciding on variety and creativity in your models. Motorized equipment examples were good choices for movement! It was clear that all the team members were involved! Good job!

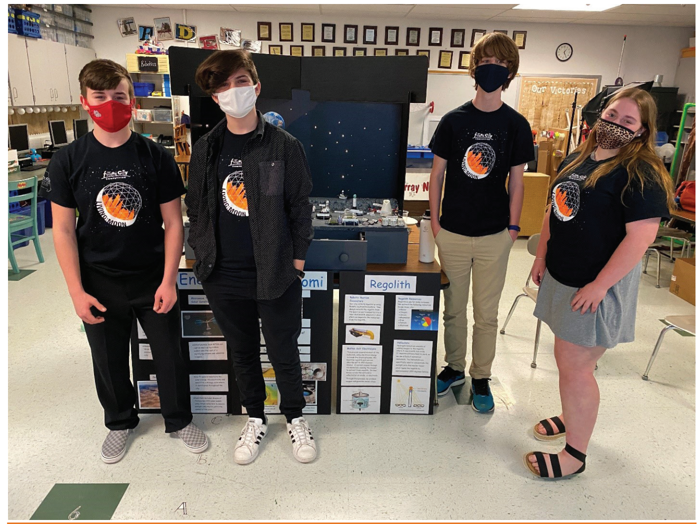
Pokemon Collectors — "Flying High"
The judges loved the great team unity and support among the team members. They noted that the project board listed ALL of the FIRST CORE values as demonstrated during their presentation! The moving models were so large and so exciting to watch. They were super creative! Loved the Ferris wheel and the details on the planes on the carnival ride. The WeDo tower winch action was very creative demonstrating some real out-of-the box thinking!

Lego Masters – "No Obstacles Too Great"
The judges loved the great inclusion among the team members! Liked the photos and statements on the left panel of the poster! The rest of poster was terrific about showing your process and some of the values. One team member showed us a great program made with the WeDo to move the fan part. Great visibility and example of the movement of the lift of flag on the tower. The judges loved hearing the special sounds you chose for when things moved, that was just fun! Good inclusion and teamwork and support of teammates when you showed the string of scenes with the team planning things out earlier in the season.

For more information, visit: thekaleidoscope.org/first-robotics

St. Clair Middle School Team "Altero Domi" Places 3rd Nationally in Future City Competition

INSPIRE UTC grant funding was used to support the Missouri Future City Competition. Teams of 6th-8th grade students were asked to engineer a sustainable city on the moon. These teams prepared project plans, wrote a research essay, built a physical model, and video taped a presentation of their city and the engineering principles that were used to model their concept. This year, both the state and national competitions were held virtually and judges interviews were conducted through Zoom.



Altero Domi representing Missouri in the National Future City Competition

The INSPIRE UTC Award was conferred on "Altero Domi" the team from the St. Clair Middle School which was also chosen to represent the State of Missouri in the national competition. This team ultimately secured Third Place Nationally, the highest placed for a Missouri team since the start of the program. Additionally, Altero Domi garnered the Best Model Award sponsored by Shell.

On the horizon? In preparation for the summer, spring break camps were conducted in a socially-distanced environment at 30% capacity. The Kaleidoscope will continue to support robotics, coding and engineering education in the region during the upcoming summer in a CDC compliant environment. We are excited to reach even more students in the 2021-2022 academic year!

All programs benefitted by the INSPIRE UTC funding allowed the Kaleidoscope to reach over 50 elementary students a year plus an additional 75 through one-day and week-long sessions, including the first in St. Robert. In addition, the Missouri Future City program reached an additional 50 students from around the state.

NSBE chapter at Missouri S&T hosts Pre-College Initiative

Every year, the National Society of Black Engineers (NSBE) chapter at the Missouri University of Science and Technology (Missouri S&T) hosts a Pre-College Initiative event. This is typically a three-day event where high achieving Black and African American high school students from surrounding areas visit campus to get immersed into college life while attending STEM workshops and presentations. This year, due to COVID-19 restrictions, the event was hosted virtually.

A presentation titled "Traffic Jam!" was presented by Dr. XB Hu, Assistant Professor in Civil, Architectural and Environmental Engineering, S&T, and Mr. Chris Yang Song, PhD student in Civil, Architectural & Environmental Engineering, S&T.

Traffic jams can be frustrating. They can also cause accidents, lead to loss of productivity, and increased fuel consumption and air pollution. In this workshop, students will take roles as transportation engineers who help find a solution to traffic jams. During the workshop, students participated in learning about the consequences of traffic and played transportation computer games which mimicked traffic lights at intersections and learned how to design traffic signals and do city planning to reduce traffic congestions.

For more information, visit: sdi.mst.edu

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UPCOMING EVENTS

June 3, 2021
Abbett Distinguished Seminar Series " Case Studies of Problematic Expansive Soils: Characterization Challenges, Innovative Stabilization Designs, and Novel Monitoring Methods" by Dr. Puppala, Texas A&M University
cii.mst.edu/events/abbettdistinguishedseminarseries/

June 16, 2021
INSPIRE UTC Webinar "FIBER OPTIC SENSOR BASED COR-ROSION ASSESSMENT IN REINFORCED CONCRETE BRIDGE ELEMENTS AND METAL PIPELINES" by Dr. Genda Chen, Missouri S&T
inspire-utc.mst.edu/webinars/

June 14-16, 2021
Council of University Transportation Centers Meeting
mycutc.org/events/summer-meeting-2021/

August 10-11, 2021
INSPIRE UTC Annual Meeting
inspire-utc.mst.edu/annualmeeting/

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